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AUTHOR Edwards, Jan; Beckman, Mary
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ABSTRACT

A series of phonetic production and perception experiments were designed to describe the phonological or phonetic domains of two effects in spoken English: final lengthening, generally interpreted as a mark for the edge of some linguistically-defined unit of speech production, and stress-timed shortening, generally interpreted as evidence for rhythmic forces that work toward equalizing the distance between stressed syllables. The results suggest that intonational phrase-final lengthening and a smaller durational effect, seeming word-final lengthening, are very different types of effects. The latter does not appear to be a phonologic boundary mark because of highly inconsistent production and perception, nor does final lengthening appear to be related to the edges of any prosodic constituent below the level of the intonational phrase, either phonologically or phonetically. It is suggested that the smaller effect is a result of articulatory timing relationships within the stress foot. (MSE)

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Perception of final lengthening

Jan Edwards (Hunter College, CUNY) and
Mary Beckman (The Ohio State University)

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Two durational effects are often cited as evidence for a hierarchical organization in English. The first is 'final lengthening,' which is generally interpreted as a mark for the edge of some linguistically-defined unit of speech production. The second is 'stress-timed shortening,' which is generally interpreted as evidence for rhythmic forces that work toward equalizing the distance between stressed syllables. The two effects are similar in that both involve an apparent adjustment of syllable duration which is dependent on some notion of linguistic constituency. However, the implied constituents are quite different and presuppose very different models of the relationship between prosodic structure and speech production. Final lengthening implies a constituent that has a clearly defined edge. In terms of rhythm, however, it need not have a phonologic head; its internal prosodic structure could be completely flat. By contrast, stress-timed shortening implies a constituent headed by a phonological prominence. But this description says nothing about edges: the unit need not be a constituent at all in the sense of having identifiable boundaries.

We have been conducting a series of experiments designed to describe the phonological or phonetic domains of the two effects. At last year's LSA meeting, we described the results of our production experiments. We will briefly review these results again in order to explain the motivation for our perception experiments.

Our initial hypothesis was that final lengthening is the durational correlate of the boundary tone that marks intonational phrase boundaries and therefore should occur only at intonational phrase boundaries.

Insert Table I here

In our first set of sentences, we contrasted the target syllable 'pop' in word-final and non-final position in the words 'pop' and 'poppa' with the word boundary either coinciding or not coinciding with an intonational phrase boundary. We made the interstress interval identical in the two phrases, thinking thus to eliminate the possibility of stress-timed shortening. We predicted that the [pa] in 'pop' would be longer than the [pa] in 'poppa,' only in the former pair of sentences in which the word boundary and intonational phrase boundary coincide.

Insert Figure 1 here

This prediction was not borne out. We did find substantially longer [pa]'s in 'pop' than in 'poppa' preceding intonational phrase boundaries for all of our speakers at three different speaking rates. However, we also found longer [pa]'s in 'pop' than in 'poppa' without a following intonational phrase boundary, although here the difference were not significant for all speakers, nor at all speaking rates.

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Insert Table II here

J. Edwards

Insert Figure 2 here

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In our second production experiment, therefore, we considered that there might be two different final lengthening effects: a large phrase-final lengthening at intonational phrase boundaries and a smaller word-final lengthening at the edge of a lower-level prosodic constituent, possibly at the edge of the accentual phrase. We contrasted 'pop' and 'poppa' in sentences with accent patterns so that the word boundary either did or did not coincide with a possible accentual phrase boundary. This experiment yielded mixed results. The [pa] in 'pop' was significantly longer than the [pa] in 'poppa' for some speakers for all accent patterns, but for other speakers, it was longer only for some accent patterns at some rates.

Thus, the second experiment left us with no clearer picture of prosodic constituents within the intonational phrase. We did not know how to describe the phonologic domain of the smaller word-final lengthening effect or even whether this smaller effect should be described phonologically. At this time, we did not consider a stress-timed shortening description of word-final lengthening since the durational differences occurred even though the target stressed syllable was always separated from the next stressed syllable by a single unstressed syllable.

Given the ambiguous results of the production experiments, we decided to test the perceptual salience of intonational phrase-final lengthening and seeming word-final lengthening. We reasoned that if these durational effects are phonologic marks of the edges of prosodic constituents, then listeners should be able to perceive the boundaries of the prosodic constituents so marked. The results of our production experiments led us to predict that words subject to intonational phrase-final lengthening would be highly discriminable. As for word-final lengthening, apriori, we considered three possible descriptions.

1. The first is that word-final lengthening occurs at well-defined edges of some prosodic constituent below the level of the intonational phrase, such as the stress foot. We could rule out the stronger hypothesis that word-final lengthening is used directly as the phonologic boundary mark of this lower-level prosodic constituent because of the variable results of our production experiments. However, the production results did not eliminate a weaker version of this hypothesis. Namely, that there is a lower-level prosodic constituent with edges that are not marked directly by word-final lengthening, but are marked by some other phonologic mark (such as the shape of the F0 pattern). This first hypothesis predicts that listeners can consistently discriminate between 'pop' and 'poppa' at the edge of this lower-level prosodic constituent. The variability of our production experiments is due to the fact that we were not measuring a directly phonologic mark of this lower-level prosodic constituent.

Our second and third descriptions of word-final lengthening assume that prosodic constituents below the level of the intonational phrase do not have phonologically-marked edges. We formulated two descriptions of word-final lengthening as a production effect.

2. In our second hypothesis, we considered the possibility that phonetic production units have well-defined edges. That is, speakers organize their talking in terms of the beginnings and endings of some lower-level prosodic constituent, such as the stress foot. The word-final lengthening we observed occurs at the edges of these phonetic production units. It may be a slowing down or braking at the end of a production

unit, or, alternatively, it may be a pause to plan at the beginning of a production unit. This hypothesis predicts that perception of word-final lengthening, a production effect, should be considerably poorer than perception of intonational phrase-final lengthening, a phonologic boundary mark. This hypothesis also predicts a strong relationship between perception and production of word-final lengthening. If the edges of the production units exist for the speaker, then only inasmuch as the speaker brakes or pauses at these boundaries, will the boundaries be perceptible to the listener.

3. Our third hypothesis is that phonetic production units are organized in terms of their heads, rather than their edges, at the level of the stress foot. The word-final lengthening we observed is a result of different foot structures (a difference we did not consider when we earlier rejected a stress-timed shortening explanation of word-final lengthening). The unstressed syllable in 'pop opposed' is an extra-metrical syllable associated with the second stress foot. In 'poppa posed,' the unstressed syllable is associated with the first stress foot. Suppose that, as a number of researchers have suggested, articulation of consonants and unstressed vowels is phased relative to the articulation of the stressed vowel within a stress foot. The longer [pa] in 'pop opposed' is due to the relatively later articulation of the unstressed syllable because of its affiliation with the second stress foot. By contrast, the shorter [pa] in 'poppa' is due to the relatively earlier articulation of the unstressed syllable because of its affiliation with the first stress foot. This third hypothesis, like the second, predicts that listeners' perception of word-final lengthening should be poorer than their perception of intonational-phrase final lengthening. In contrast to the second hypothesis, it does not predict a relation between production and perception of word-final lengthening: since word-final lengthening is not a consequence of production units with well-defined edges where speakers might brake or pause, there is no reason to assume that listeners perceive the boundaries of these units only inasmuch as syllables at the ends of these units are longer.

We ran two perception experiments which parallelled our two production experiments. In the first, we used the four phrases 'pop opposed,' 'poppa posed,' 'pop, opposing,' and 'poppa posing' from the utterances of two speakers recorded in the first production experiment. In the second, we used the three different accent patterns for the phrases 'her pop opposed' and 'her poppa posed' from the utterances of four speakers recorded in the second production experiment. For both experiments, we took five tokens of each phrase at two different speaking rates (slow and normal). We blocked the stimuli by speaker and rate and grouped them into sequences of five with a tone separating each group. 15 adult native speakers of American English served as subjects for both perception experiments. We instructed the subjects to choose between the two phrases for each item and to guess if they were unsure.

Insert Figure 3 here

The results of the first perception experiment confirm our prediction that intonational phrase-final lengthening is highly discriminable. Listeners were close to 100% accurate at distinguishing between 'pop' and 'poppa' at intonational phrase boundaries. Listeners could also distinguish between 'pop' and 'poppa' within an intonational

phrase at better than chance level. However, perception of word-final lengthening is significantly poorer than perception of intonational phrase-final lengthening.

Insert Figure 4 here

We observed similar results in our second perception experiment. Listeners could discriminate between 'pop opposed' and 'poppa posed' at better than chance level for some speakers, for some accent patterns, and at some rates. Again, listeners' discrimination of word-final lengthening is considerably poorer than their near perfect discrimination of intonational phrase-final lengthening.

Thus, in both perception experiments, listeners had difficulty in discriminating edges of prosodic constituents below the level of the intonational phrase. This result rules out hypothesis one: lower-level prosodic constituents do not appear to have phonologically-marked edges. In order to differentiate between hypothesis two--that word-final lengthening is a result of braking or pausing at the edges of production units--and hypothesis three--that word-final lengthening is a result of articulatory phasing relationships within the stress foot--we needed to determine whether acoustic duration patterns could predict listeners' perception of word-final lengthening. For each stimulus item, we analyzed percent correct (totalled across listeners) as a function of the interaction between the ratio of the duration of [pa] to the following schwa. We used a somewhat complex regression model because of the different relationships between this ratio and prceptions of 'pop,' as compared to 'poppa.' 'Pop opposed' is more likely to be perceived as this ratio increases: that is, as the [pa] duration increases relative to the schwa duration. By contrast, 'poppa posed' is more likely to be perceived as this ratio decreases: that is, as the [pa] duration decreases relative to the schwa duration. Thus, we assumed that the functions relating percent correct to the ratio of [pa] to schwa duration were likely to have different slopes for the two words. Therefore, we analyzed percent correct as a function of the interaction between the ratio of [pa] to schwa duration and word identity and included word identity and accent pattern as covariates.

Insert Figure 5 here

This regression model explained a significant percentage of the variance (about 50%) for only one of our four speakers. He is one of the two speakers in the perception experiment who consistently produced word-final lengthening across different accent patterns and speech rates. The regression model did not explain a significant percentage of the variance for the other speaker with consistent production of word-final lengthening, nor for the two speakers with variable production of word-final lengthening. These results--although not conclusive--tend to support hypothesis three over hypothesis two: even when speakers produce word-final lengthening, listeners do not consistently perceive the boundaries of these lower-level prosodic constituents.

Thus, the results of the production and perception experiments, taken together, suggest that intonational phrase-final lengthening and the smaller durational effect, seeming word-final lengthening, are two very different types of effects. Intonational phrase-final lengthening is a

phonologic mark of the edge of an intonational phrase: speakers consistently produce longer syllables in intonational-phrase final position; and listeners can consistently use intonational phrase-final lengthening to discriminate between phrases which are otherwise phonetically identical.

By contrast, the smaller effect does not appear to be a phonologic boundary mark. We found considerable variation both within and across speakers with respect to whether final syllables were longer than matched non-final syllables at the edge of all lower-level prosodic constituents. Furthermore, we found that listeners were consistently less accurate at discriminating between these final and non-final syllables, with performance at chance level for some speakers. Finally, listeners' perception of this smaller effect was not correlated with speakers' production of it for three of our four speakers.

These results suggest that the smaller durational effect is not a phonologic mark of a prosodic constituent boundary. Indeed, we found no evidence that final lengthening is related to the edges of any prosodic constituent below the level of the intonational phrase, either phonologically or phonetically. We suggest that our third interpretation of the smaller effect--that it is a result of articulatory timing relationships within the stress foot--is most likely to be correct. We have therefore begun to look at these articulatory timing patterns directly.

Table I
Intonational Phrasing Corpus

1a. Pop, opposing the question strongly, refused to answer to it.
1b. Poppa, posing the question loudly, demanded an answer to it.

2a. Pop opposed the question strongly, and so refused to answer it.
2b. Poppa posed the question loudly, and then refused to answer it.

Table II
Accentual Phrasing Corpus

1. Post-nuclear position
   Q. Did his dad pose a problem as far as their getting married?
   A1. HER pop opposed the marriage.
   A2. HER poppa posed a problem.

2. Pre-nuclear, unaccented
   Q1. Did his dad feel strongly about their marriage?
   A1. HER pop OPPOSED the marriage.

   Q2. Was his dad involved in solving their problems?
   A2. HER poppa POSED a problem.

3. Nuclear position
   Q. Was her mom against their getting married?
   A1. Her POP opposed the marriage.
   A2. Her POPPA posed a problem.

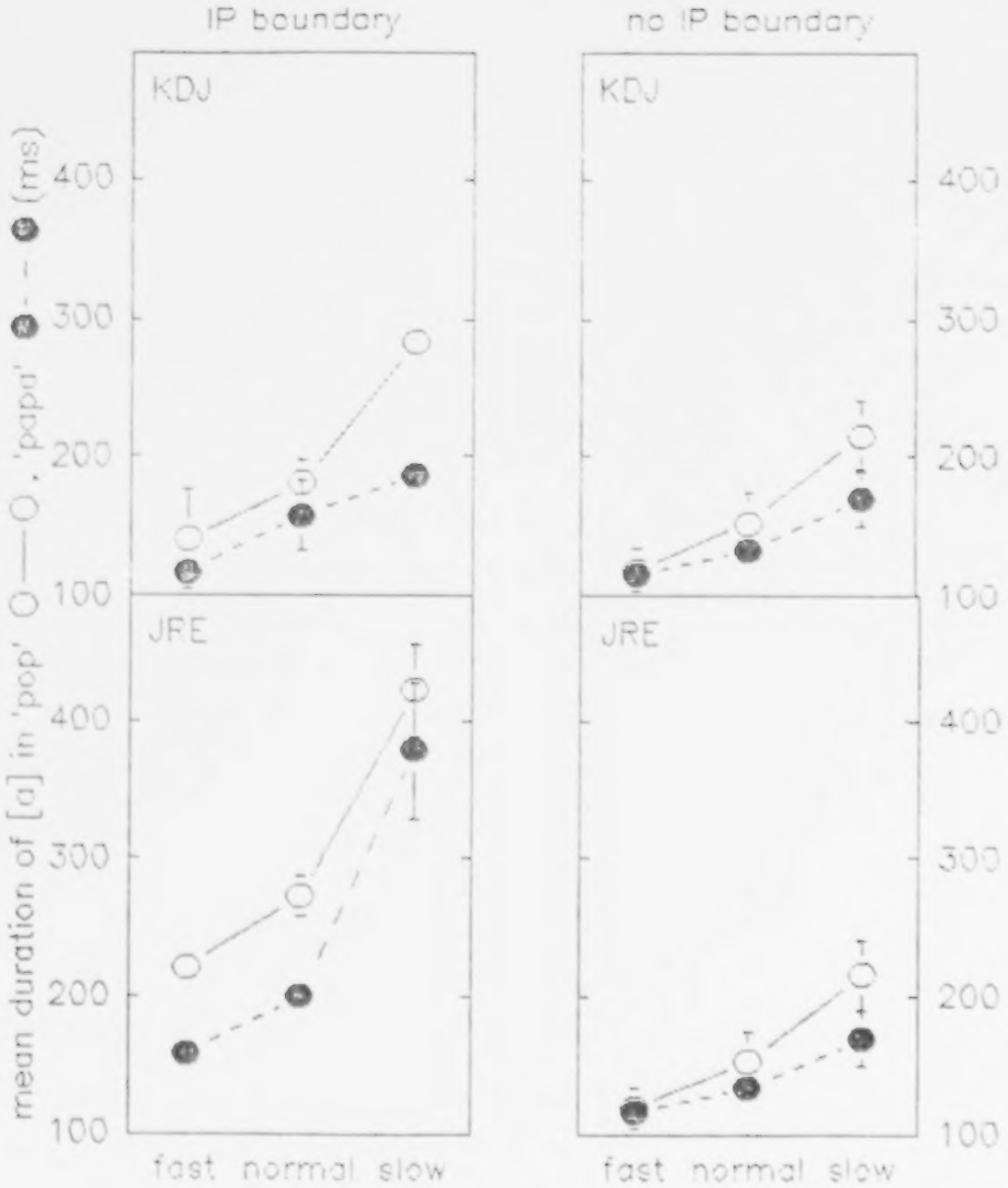

Figure 1: Mean duration of [a] for two subjects in contexts in which the word boundary either coincides or does not coincide with an intonational phrase boundary.

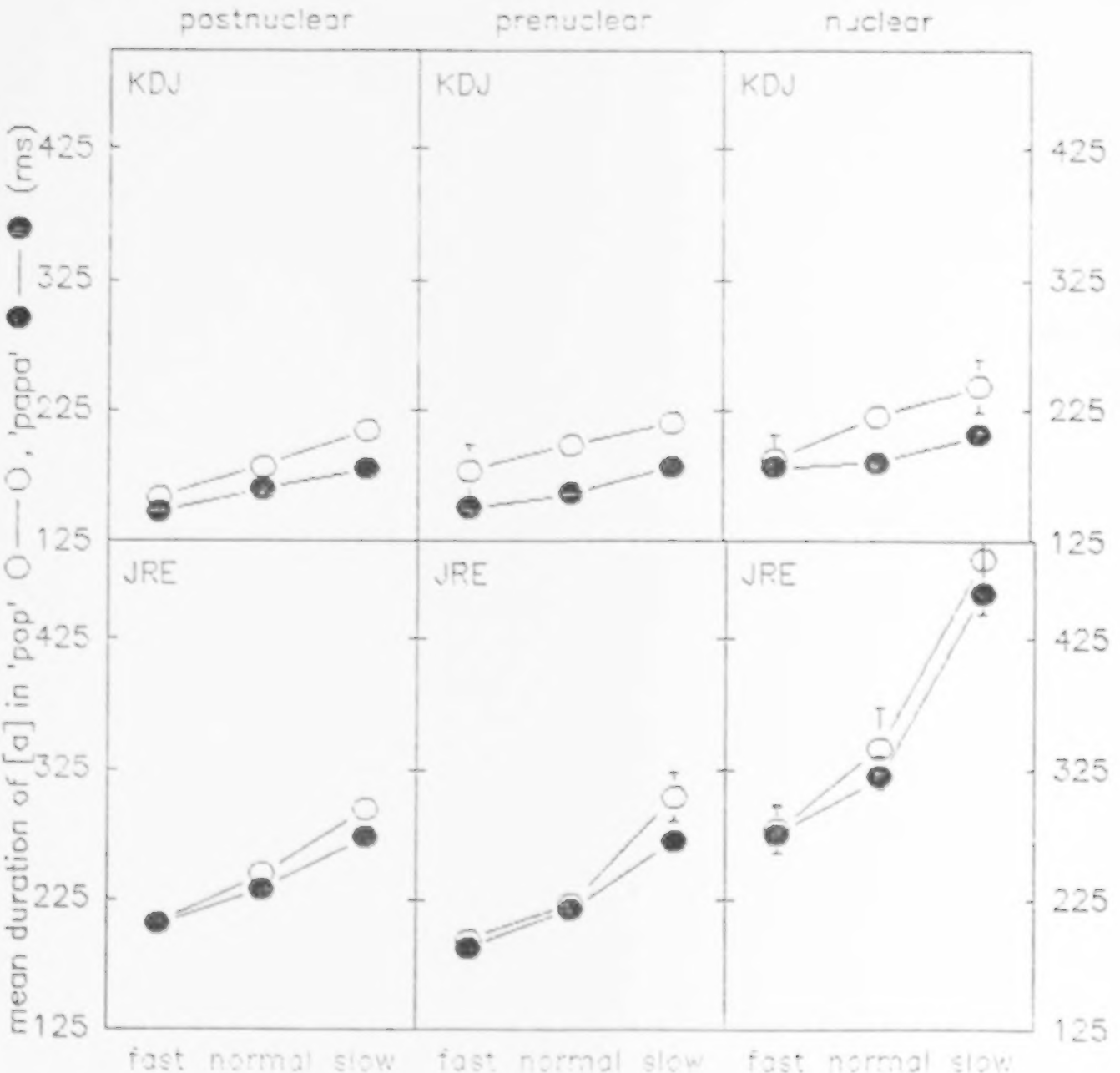

Figure 2: Mean duration of [a] for two subjects in contexts in which the word boundary either coincides or does not coincide with an accentual phrase boundary.

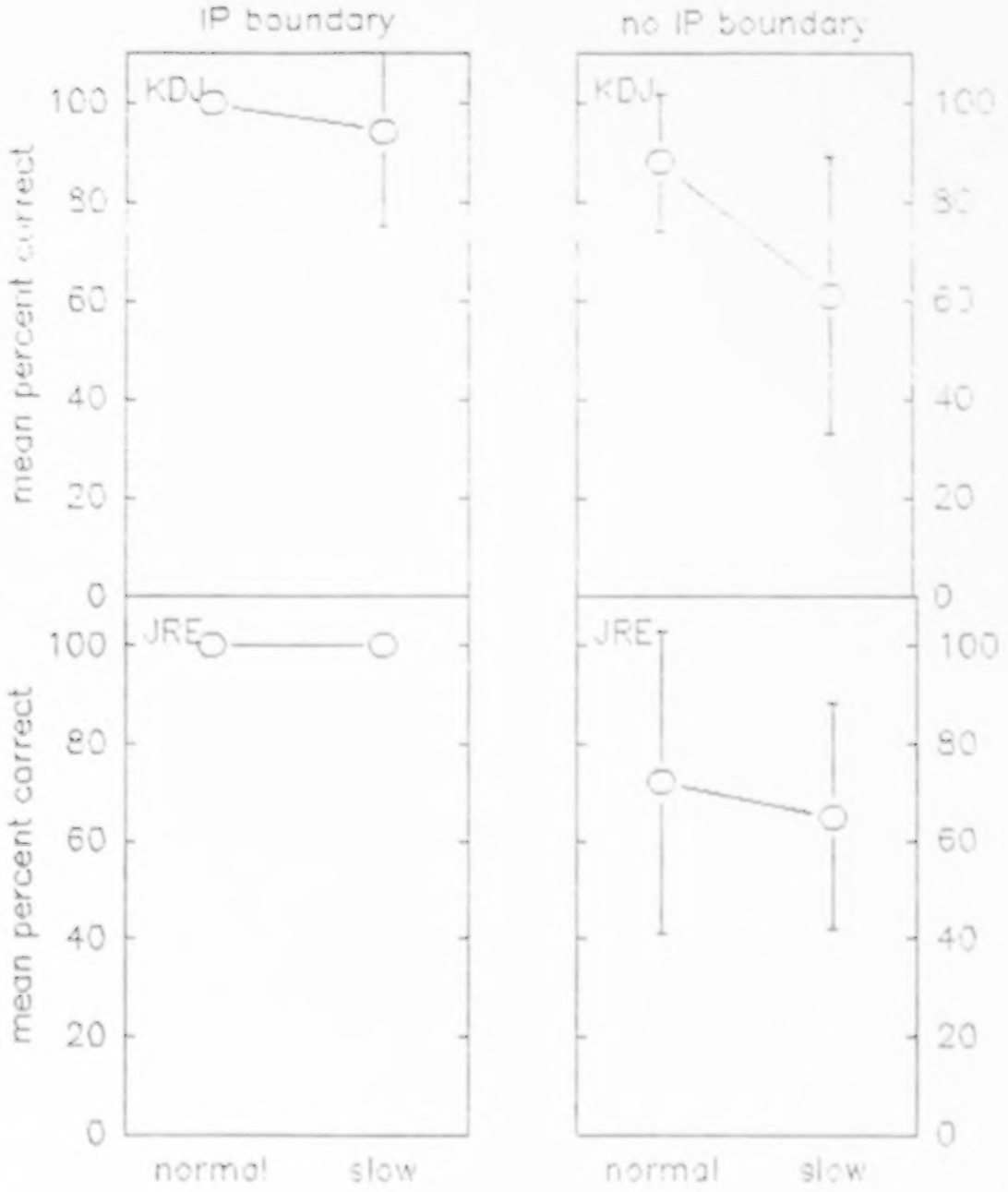

Figure 3: Mean percent correct (averaged across listeners) for two speakers for the phrases 'pop opposed' and 'poppa posed' in which the end of the first word either coincides or does not coincide with an intonational phrase boundary.

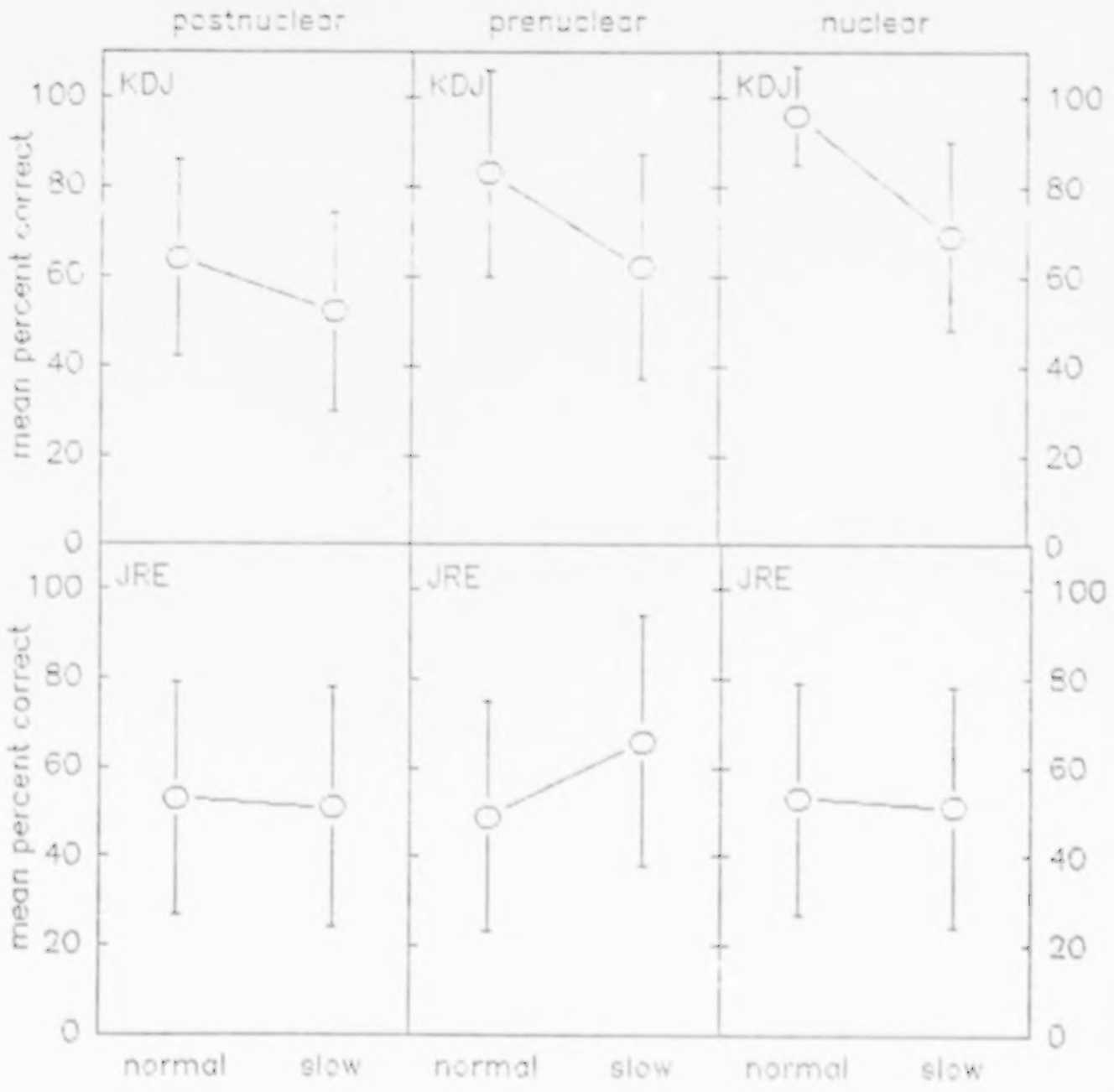

Figure 4: Mean percent correct (averaged across listeners for two speakers for the phrase 'pop opposed' and 'poppa posed' with three different accent placements for the first word (postnuclear, prenuclear, or nuclear position).

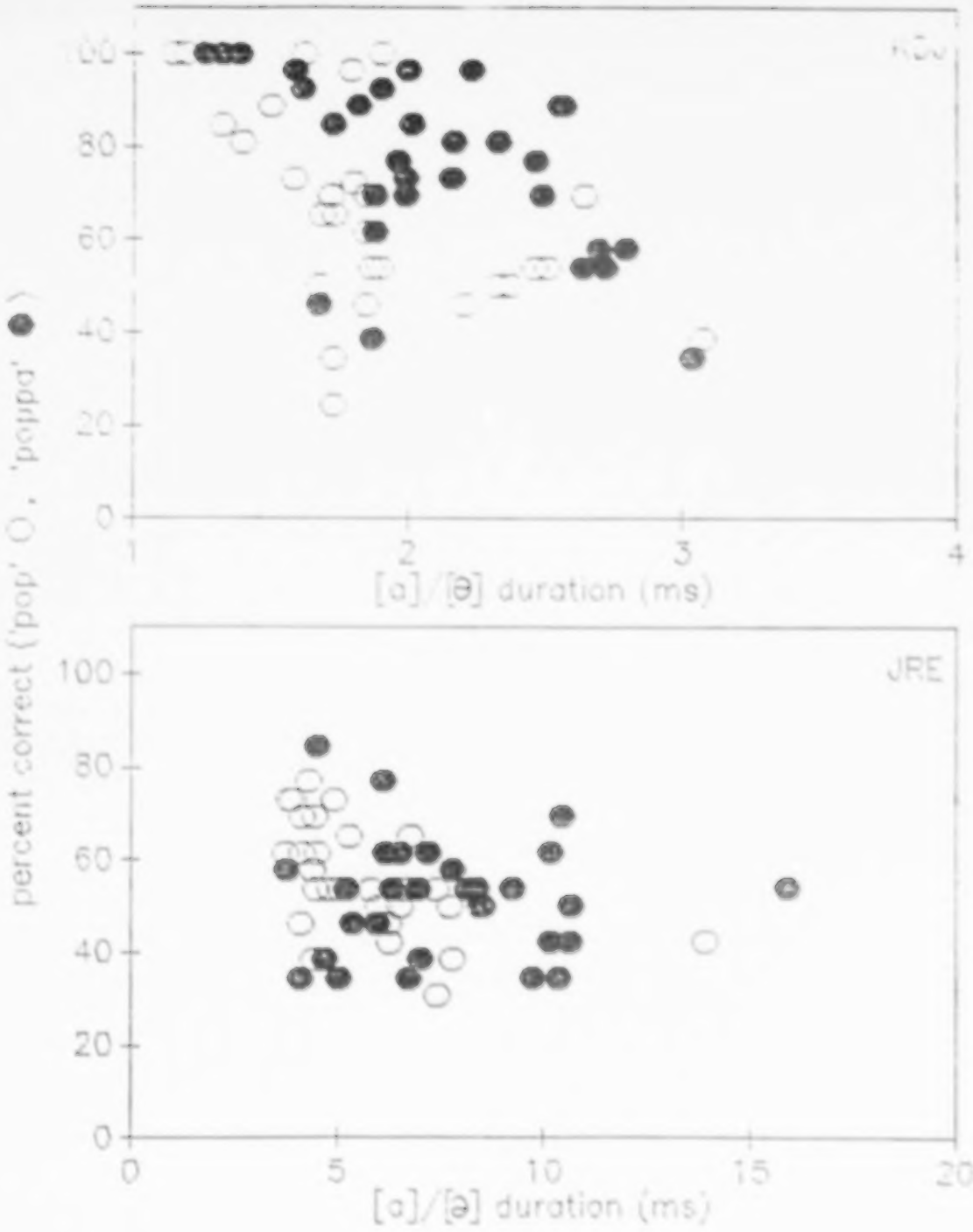

Figure 5: Percent correct (totalled across listeners) as a function of the ratio of [ɑ] to schwa duration for two speakers.

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